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(71) Applicant : **ROHM AND HAAS COMPANY**
Independence Mall West
Philadelphia Pennsylvania 19105 (US)

(72) Inventor : **Ludwig, Edward Garland ,Jr.**
250 Chemin de Sartoux
F-06370 Mouans-Sartoux (FR)
Inventor : **Ushida, Shinzo**
3-10-10, Tatsuta-river Heguri-cho
Ikoma-gun, Nara Pref. 636 (JP)

(74) Representative : **Angell, David Whilton et al**
ROHM AND HAAS (UK) LTD. European
Operations Patent Department Lennig House
2 Mason's Avenue
Croydon CR9 3NB (GB)

(54) **Method for hiding scratches or imperfections on the surface of screens used in projection system.**

(57) Translucent sheet having a thickness of from 0.1-5 mm and comprising synthetic resin matrix containing higher diffusing polymer particles and having 80% or more of light transmittance, especially compositions as disclosed in EP-A-0269324 and EP-A-0342283, are useful covers for rear projection screens, hiding scratches or other imperfections thereon.

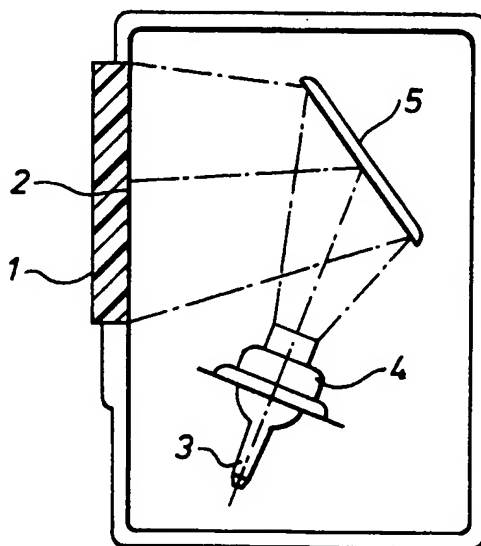


Fig.1.

The present invention is concerned with a method for hiding scratches or imperfections in a rear projection screen such as TV screen, rear projected slides, liquid crystal display (LCD) screens or thin layer electric decol-

loration sheet. The method involves the use of plastic sheet containing a specific light diffusing particles therein.
 In recent television technologies, screens for Braun tubes are limited to sizes of less than 127 cm (50
 5 inches) even in large screen televisions because the inside of a cathode ray tube is under vacuum. A larger TV screen can be used in rear projected displays. There are two types of projected displays, rear projected and front projected. Slides are generally front projected on to a white cloth or white plastic screens. When a translucent sheet is used, rear projection may also be used in viewing slides.

Further, along with the recent development of LCD technology field, various liquid crystal displays are begi-
 10 nning to be used in electronics field.

EP-A-0269324 and EP-A-0342283 disclose excellent light transmittance plastics material which in sheet form is translucent and also the use of light diffusing compositions as a rear projection screen.

The various image screens or display sheets heretofore mentioned are shaded or darkened if they have scratches or imperfections on the surface. Therefore, most careful handling is required in supply of these materi-
 15 als for projected image screens. We have now found that light diffusing compositions such as those disclosed in the above identified European Patent Applications are surprisingly effective in hiding defects such as scratches or other surface imperfections when images from various sources are projected onto such screens. The present invention relates to use of the light diffusing compositions such as these described in the EPC publications as screens for LCD's or screen covers for cathode ray tube screens.

We have now found that plastic sheets comprising the polymer composition disclosed in EP-A-0269324 and EP-A-0342283 cause no significant distortions, bright or dark, on projected image even if the plastic sheet has scratches or other minor imperfections on the surface to which images may be projected.

Generally, a scratch or imperfection on the surface of any material changes the light scattering effects in the vicinity of the scratch and imperfections can appear as either a bright or dark image. Such an image is visible
 25 through a typical diffusing material because light passing through the scratch or imperfection is backscattered to a different degree.

Thus, a brighter or dimmer image of the scratch or imperfection relative to the brightness of the rest of the screen occurs and is visible. However the plastic sheet comprising polymer compositions disclosed in the above EP Applications does not backscatter light significantly but does efficiently diffuse light, so the image of a
 30 scratch or imperfection is diffused and hidden. The use of said polymer composition as a diffusing sheet for a rear projection screen or backlit LCD screen is of benefit to such screen manufacturers. Because minor scratches or imperfections can be hidden and not easily detected by an observer, the productivity for such products can be increased since the reject rate can be decreased and this is of particular economic significance for recent LCD displays or color TV screens which cannot be permitted to have any scratches or imperfections.

In the sheet, synthetic resins are used as matrices. Examples of synthetic resins used herein include, but are not limited to, polyolefinic resins such as polyethylene and polypropylene; olefin-vinyl acetate copolymers; resins of polyalkyl (meth)acrylates such as polymethyl (meth)acrylate; vinyl chloride resins; polyesters; polyamide resins such as nylons; polycarbonate; polystyrene; styrene-acrylonitrile copolymers polyvinylidene fluoride, and polysulfones, phenol type resins alone or in combination or as copolymers.

40 The foregoing synthetic resins preferably have both heat resistance and impact resistance.

The sheet used in the invention is characterized in that a light diffusing agent is contained in a matrix composed of one or more of the foregoing synthetic resins listed. As the light diffusing agent, particles of an organic polymeric compound are preferred because of their proper light transmittance and excellent light diffusion properties and specific examples thereof include alkyl (meth)acrylate type resins, monovinylarene type resins
 45 such as styrene type resins and vinyl carboxylate resins. These light diffusing agents may be homopolymers, copolymers or mixtures as well as multi-staged polymeric materials. Preferred are alkyl acrylate type resins and more preferably used are those comprising a core of such alkyl acrylate resins which are further covered with layers of the foregoing resins. Examples of the latter are polymer particle compositions as disclosed in EP-A-269324 and 0342283 which in turn are as follows:

50 EP-A-0269,324 describes particles of core/shell polymer having an average diameter of from 2 to 15 μ m, a particle size distribution such that at least 90% by weight of the particles fall within $\pm 20\%$ of the average particle diameter, a core of rubbery alkyl acrylate polymer, the alkyl group having from 2 to 8 carbon atoms, copolymerised with 0 to 50% copolymerisable vinyl monomer, 0 or upto 5% crosslinker and 0 or upto 5% graftlinker (based on the total weight of the core) and having a refractive index (n_D^{25}) within 0.2 units of, but preferably
 55 no closer than ± 0.003 to, the refractive index of the matrix polymer, and one or more polymer shells, the outer most of which is compatible with the matrix polymer, which shells comprise from 5 to 40% of the weight of the particles;

EP-A-0342283 describes other substantially spherical polymer particles having an average of from 2 to 15 micrometers and a particle size distribution such that at least 90% by weight of the particles fall within $\pm 20\%$ of the average particle diameter. Other preferred compositions useful in the present invention should be obtained from the disclosures of said EP Applications.

5 The light diffusing agent particles used are in general substantially spherical in shape and their average particle size is in the range 0.1 to 500 microns. The term "average particle size" is herein referred to that determined by a Nanosizer. Moreover, the particles preferably have a particle size distribution in which the particle size of at least 90% by weight of the particles falls within the range of the average particle size of $\pm 20\%$. The refractive index (n_D) of the light diffusing agent preferably has the following correlation with the refractive index of the foregoing matrix synthetic resin (n_M) in view of obtaining good diffusion properties:

$$0.003 \leq |n_M - n_D| \leq 0.2$$

(the term "refractive index" herein means (n_D^{λ})).

The aforesaid light diffusing agent particles are incorporated into the foregoing synthetic resin (matrix) in an amount from 0.1 to 40% by weight. These particles are preferably dispersed in the matrix uniformly, for good light diffusion properties.

15 Particularly preferred materials which comprise synthetic resins and light diffusing particle agents mixed and dispersed therein are polymer compositions as disclosed in the above-identified EP-Applications. More specifically, the polymer compositions are thermoplastic or thermosetting polymer compositions which comprise thermoplastic or thermoset matrix polymer and light diffusing polymer particles dispersed in the matrix in an amount ranging from 0.1 to 40% by weight on the basis of the total weight of the composition, the polymer particles having an average particles size from 2 to 15 microns and a particle size distribution in which the particle size of at least 90% by weight of the particles falls within the range of the average particles size $\pm 20\%$ and the particles being substantially spherical in shape. When the polymer composition is a light scattering composition based on a thermoplastic polymer matrix and the spherical polymer particles constitute 0.1 to 10% by weight of the total weight of the composition, particularly preferred spherical polymer particles are core/shell polymer particles composed of a core of a rubber-like alkyl acrylate polymer (wherein the alkyl group has 2 to 8 carbon atoms) which is copolymerized with up to 5% of a cross-linking agent with up to 5% of a graft linker (the amount is based on the total weight of the core) and whose refractive index n_D^{λ} is in the range of that of the matrix polymer (n_M) ± 0.2 , preferably out of the range of the refractive index (n_M) ± 0.003 ; and at least one polymer shell (the outermost layer is compatible with the matrix polymer and where the shell(s) constitute 5 to 40% of the weight of the particle).

The particles of the light diffusing agent may be mixed with and dispersed in the synthetic resin according to any known manner, for example by: (1) a method comprising kneading a synthetic resin and a light diffusing agent in an extruder and then forming the mixture into a sheet, (2) a method for forming a sheet according to a co-spray method; and (3) a method (disclosed in U.S.-A-3,751,527) comprising mixing an emulsion type synthetic resin and an emulsion containing particles of the light diffusing agent, coagulating the both together utilizing coagulant and then molding it.

In the Figures:

Figure 1 represents a rear projection system for Television.

40 Figure 2 represents a liquid crystal display.

Figure 3 represents a thin electric display decoration message board.

In Figure 1, a cover (1), protects the outside of the light diffusing polymeric screen (2) from objects that might come in contact with and damage the projection screen. The image bearing beams emanating from the cathode ray tube (3) is focused by a lens (4) on the projection mirror (5). The image bearing beams are reflected from the projection mirror (5) onto the rear side of the light diffusing polymer screen (2). Any manufacturing defects such as scratches or imperfections in the light diffusing polymer screen (2) are minimized by the use of the light diffusing agent of the present invention when used in the synthetic resin matrix.

Figure 2 represents a display system that transforms data from an electrical domain to an optical domain. The system can be used for digital displays from liquid crystals (LCD) and visible light emitting diodes (VLED) as used in such products as electronic watches, calculators, microwave oven controls, computer connect display systems, VCR displays and has the potential in the manufacture of flat thin television screens. The liquid crystal display (LDC) (8) is sandwiched between two light diffusing polymer sheets (1), with appropriate electrodes (7) adjacent to the liquid crystal to provide a means for displaying changes in electrical signals. The light diffusing polymer sheets (1) are sandwiched between upper and lower transparent polarizable plates (6). The lower polarizable plate (6) may be coated on its outside surface with a diffuse reflector, i.e., a mirror.

55 Figure 3 represents the use of a light diffusing polymer sheet in a relatively thin edge light type of decoration board. In such a system the message to be conveyed may be a pattern of the message affixed on the reflection

surface of panel (10). Light sources (11) provide a means to reflect light from surface of panel (10) to and through the light diffusing polymer sheet (1). The message affixed on panel (10) then appears as a darkened pattern on the surface of the light diffusing polymer sheet (1).

Light diffusing polymer composition sheets used in actual examples described above are prepared as follows. The thickness of the sheet is about 3 mm.

(1) Manufacturing example of light diffusing polymer particles.

	<u>Components</u>	<u>Amount parts by weight(pbw)</u>
10	<u>Mixture A</u>	
	Water	162
	Potassium carbonate	0.12
15	<u>Mixture B</u>	
	Butyl acrylate	66
	Styrene	15
	<u>n</u> -Octyl mercaptan	19
20	10% Aqueous solution of sodium dodecylbenzene-sulfonate	5.3
	Water	19
	<u>Mixture C</u>	
25	Potassium persulfate	0.014
	Water	1.4
	<u>Mixture D</u>	
30	Potassium persulfate	0.014
	Water	8.3

Step A

35 Mixture A was charged into a reactor provided with a stirrer and a condenser and blanketed with nitrogen gas and heated to 87° C.

To the stirred reactor contents there were added 7% of the mixture B and all of the mixture C and the contents were stirred for 30 minutes. Thereafter, the remaining mixture B and the mixture D were added to the contents over 90 minutes with stirring. The contents of the reactor were maintained at 87° C for 50 minutes with stirring, then the resultant Step A polymer emulsion was cooled to room temperature.

The particle size of the resultant polymer (butyl acrylate-styrene copolymer) particles contained in the Step A polymer emulsion was determined by a Nanosizer and was found to be about 0.3 micron.

Step B

45 Furthermore, the following mixtures was prepared:

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	<u>Components</u>	<u>Amount (pbw)</u>
	<u>Mixture A</u>	
5	Butyl acrylate	98
	Butylene glycol diacrylate	0.50
	Alkyl methacrylate	2.0
	Benzoyl peroxide	0.80
10	<u>Mixture B</u>	
	Magnesium p-nitrosophenolate	0.011
	Water	226
15	10% Aqueous solution of sodium dodecylbenzenesulfonate	3.1
	<u>Mixture C</u>	
	Step A polymer emulsion	1.5

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The Mixture A and B were admixed with each other in a Waring Blender for 3 minutes to obtain an emulsion. This emulsion was introduced into a pressure reactor to which 1.5 pbw of Mixture C Step A polymer emulsion had been charged and the contents of the reactor were stirred for one hour under a nitrogen blanket. The reactor was sealed, was shaken at 68° C for 3 hours in a water bath and then cooled to room temperature. The resultant

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Step B polymer emulsion contained a polymer having a particle size of about 2 microns.

Step C

The procedure of aforementioned Step B was repeated, except that 23 pbw of the Step B emulsion polymer was used rather than Step A polymer emulsion. The polymer particles in the Step C polymer emulsion had a diameter of approximately 5 microns.

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Step D

The following mixture was prepared:

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	<u>Components</u>	<u>Amount (pbw)</u>
	<u>Mixture A</u>	
40	Step C polymer emulsion	1348
	<u>Mixture B</u>	
45	Methyl methacrylate	96
	Ethyl acrylate	4.0
	<u>Mixture C</u>	
	3% Aqueous sodium formaldehyde sulfoxylate	10
50	10% Aqueous sodium dodecylbenzene-sulfonate	1.5
	Water	53
	<u>Mixture D</u>	
55	t-Butyl hydroperoxide	0.45
	Water	14

Mixture A (Step C polymer emulsion) was weighed into a reactor equipped with a stirrer and a condenser

and blanketed with nitrogen. The reactor contents were heated to 85° C and stirred under the nitrogen blanket. Mixtures B, C and D were separately added to the reactor over a period of 90 minutes. The temperature was maintained at 55° C and stirring was continued for 30 minutes, after which the reactor contents were cooled to room temperature. The resulting particles in the Step D polymer emulsion were about 5 microns in diameter,

5 with less than about 20% by weight of particles less than about 5 microns in diameter.
The light diffusing agent (multi-stage polymer) thus prepared has a refractive index (n_D^{25}) of 1.46.

(2) Preparation of a light diffusible resin composition

10 The light diffusing agent obtained in Step D above was coagulated with a calcium hypophosphite coagulant to isolate it from an aqueous suspension and 5 parts by weight of the light diffusing resin agent was melt-blended at 232° with 15 parts by weight of a synthetic matrix resin. In this example a poly(methyl methacrylate) resin molding powder having a weight-average molecular weight of about 120,000 was the matrix resin.

15 The refractive index (n_D^{25} of poly (methyl methacrylate) used herein as the matrix for the surface layer was 1.49.

(3) Preparation of sheet

20 Prepared light diffusible resin composition was molded into sheet having 3 mm thickness by using an extruder.

Claims

- 25 1. The use, as a screen cover for hiding scratches or imperfections on the surface of projection screens, of a translucent sheet having a thickness of from 0.1 - 5 mm and comprising synthetic resin matrix containing light diffusing polymer particles and having 80% or more of light transmittance.
- 30 2. The use of claim 1 wherein the light diffusing polymer particles are substantially spherical and have a diameter from 2 to 15 micrometres and a size distribution such that 90% by weight of the particles are within $\pm 20\%$ of the average particle diameter.
- 35 3. The use as claimed in claim 1 or 2 of the translucent sheet as a screen in a rear projection system, a display system transforming electrical domain to optical domain, edgelit decoration board, sidelit decoration board or backlit decoration board.
- 40 4. The use as claimed in any preceding claim wherein the synthetic resin matrix comprises thermoplastic or thermoset polymer and, distributed throughout the polymer, from 0.1% to 40% of the total composition weight of spherical polymer particles having an average diameter of from 2 to 15 μm and a size distribution such that at least 90% by weight of the polymer particles fall with $\pm 20\%$ of the average particle diameter.
- 45 5. The use as claimed in any preceding claim wherein the light diffusing polymer particles comprise rubbery alkyl acrylate copolymer, the alkyl group having from 2 to 8 carbon atoms.
6. The use as claimed in claim 5 wherein the alkyl acrylate copolymer is a copolymer of alkyl acrylate and one or more copolymerizable monovinyl monomers selected from alkyl methacrylates and vinyl arenes.
7. The use as claimed in claim 6 wherein the copolymerizable monovinyl monomer comprises styrene.
- 50 8. The use as claimed in any of claims 5 to 7 wherein the alkyl acrylate copolymer is surrounded by one or more shells, the outer of which is compatible with the matrix polymer, and which comprise(s) from about 0.1 to about 40% of the weight of the particles.
- 55 9. The use as claimed in any preceding claim wherein the light diffusivity of the polymer particles is higher than that of the matrix polymer and the polymer particles have a refractive index within ± 0.2 units of, but no closer than ± 0.003 units to, the refractive index of the synthetic resin matrix.

- 10.** The use as claimed in any preceding claim wherein from 0.1 to 10 % weight of polymer particles, based on weight of matrix polymer, are distributed throughout the synthetic resin matrix polymer.

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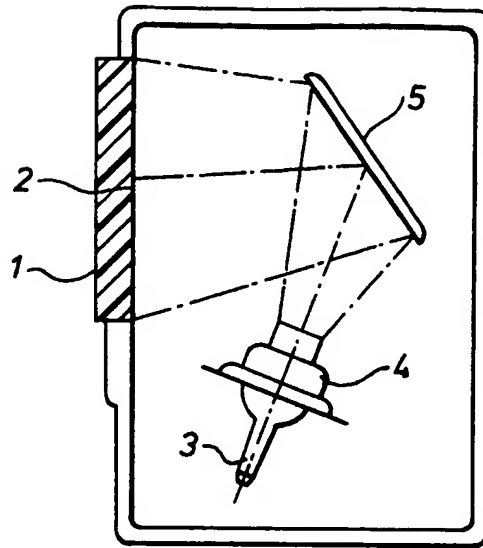


Fig.1.

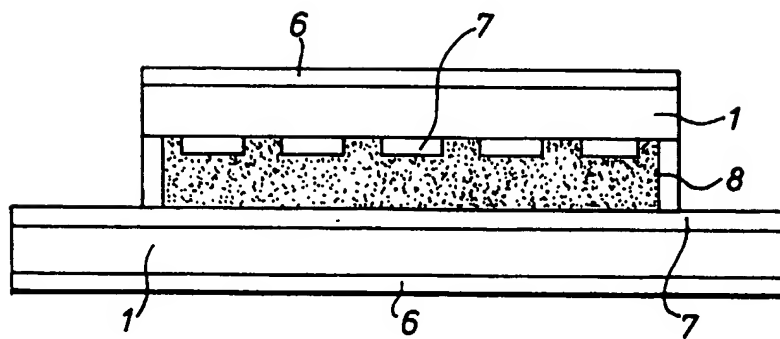


Fig.2.

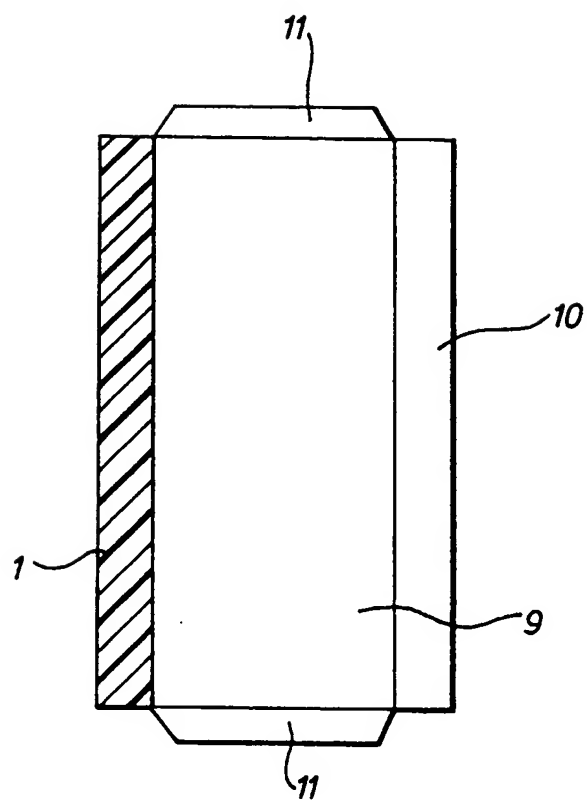


Fig. 3.



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 0225

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	WD-A-8 704 532 (J.V. SAARILAHTI) * abstract; figures 1,2 *	1-10	G03B21/62 C08F265/04
D, Y	EP-A-0 342 283 (ROHM AND HAAS COMPANY) * page 2, line 5 - line 14 * * page 3, line 18 - page 4, line 42 *	1-10	
A	GB-A-2 043 979 (TIMEX) * abstract; figures 1,2 * * page 1, line 97 - line 112 *	1,3	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			G03B C08F G02F
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 13 APRIL 1992	Examiner MANNTZ W.
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